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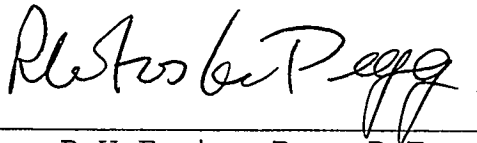
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Invention # 604

The fifth quarterly report of the above grant and
invention is enclosed as required by the contract.

Sincerely



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COAL AIR TURBINE "CAT" PROGRAM
INVENTION 604

BY

R. W. FOSTER-PEGG

FIFTH QUARTER PROJECT REPORT (October-December 1995)

DECEMBER 31, 1995

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0- 1.0 Project Objective

The primary objective of this "CAT" project is to complete a conceptual design of this unique new combination of existing technology with cost estimates to show that the "CAT" system offers the economic incentive with low technical risk for a plant to be built which will demonstrate its viability.

The technologies involved in the components of a "CAT" plant are proven, and the integration of the components into a complete plant is the only new developmental activity involved.

Industry and the Federal General Services Administration (GSA), require the demonstration of a "commercial plant" before the viability of a new concept is accepted. To satisfy this requirement the construction of a plant of commercially viable size in excess of 15 MW if cogeneration and above 30 MW if all power, is proposed. This plant will produce economical power and heat for the owner. The plant will operate for a full commercial life and continue as an operating demonstration of the viability of the technology, gathering long term life and maintenance data, all adding to the credibility of the concept.

2.0 Project Overview

The "CAT" System is an innovative new use of existing technology in a unique configuration which will be more cost effective than competitive systems.

In layman's language a Coal Air Turbine "CAT" generates electric power or cogenerates electric power and heat for process use from the burning of coal. Cogeneration, the sequential generation of electricity and heat, is more efficient and economical than their separate production.

Commercial "CAT" power plants with outputs up to 100 MW will be the outcome of this program. The "CAT" plants are expected to be 10% more cost effective than current state of the art plants with the same output.

The major components of "CAT" plants are an air turbine, a heater of compressed air, a coal combustion system, means to recover waste heat and a steam turbine when appropriate. An air turbine is the same as a gas turbine except that it runs on hot air.

The "CAT" plant burns raw coal in a fluid bed at atmospheric pressure. The air turbine operates on clean compressed air heated inside tubes immersed in the fluid bed, thus it is called an "Air Turbine" and the cycle is called a Coal Air Turbine, or "CAT", cycle. Heat is recovered from the exhaust of the air turbine and the coal combustor, to produce steam for process use and / or for driving a steam turbine to generate more power. In a version producing only electric power, the steam is expanded in a steam turbine, condensed and recirculated, instead of the steam being exported for an external use.

Gas turbines now built operate at hotter temperatures than air heaters can produce and if operated at the lower temperatures which air heaters can deliver would be less efficient and more costly. Thus, gas turbines built in the past, which operate with a turbine inlet temperature matching the temperature capability of fluid bed air heaters, are more suitable for "CAT".

Until new gas turbines are again made available for temperatures suitable for air heaters, surplus used gas turbines will be purchased, reconditioned and modified to use hot air from the air heater instead of from combustors.

The operation of fluid bed air heaters has been proven by DOE and others in many tests extending over twenty years. Many metal alloys in many configurations of fluid bed air heaters have been operated for thousands of hours. Suitable alloys and arrangements have been identified. Manufacturers now offer air heaters for the proposed operating conditions with normal commercial warranties. A Circulating Fluid Bed (CFB) combustor will be used to burn the coal. The CFB emits the least sulfur, oxides of nitrogen and particulate material of all the coal combustion systems and meets the most rigorous emission regulations.

In "CAT" cycles, heat can be recovered from the clean, breathable hot air exhausted by the air turbine for production of steam for coal drying, paper drying, building heat or more power generation.

The following features will result in the production of low cost power by a "CAT" plant:

1. Inexpensive, plentiful coal fuel.
2. Simple efficient coal combustion at atmospheric pressure. (Not pressurized fluid bed or gasification.)
3. Simple emission control by limestone and baghouses.
4. A steam turbine for power generation is unnecessary for cogeneration (but may be used if advantageous).
5. The low cost, low temperature used gas turbines are readily available.

Where coal is competitive, a "CAT" plant will be more economical at capacities above 10 MW for cogeneration and for power generation at capacities above 30MW.

3.0 Project Progress Summary

The comprehensive technical and cost information relating to one of the circulating fluid bed air heater systems which has been proposed has been shipped to R.W. Foster-Pegg. This should be received by late January.

The organization providing this information, is associated with one of the companies previously solicited and wishes to remain anonymous. The organization will provide information on a circulating fluid bed air heater system which was part of a serious commercial proposal of a "CAT" cogeneration plant in 1985. The plant was not constructed because the company to which it would have been supplied lost market share to foreign competition. The system is somewhat smaller than the "CAT" plants now being investigated. The cost of the circulating fluid bed system will be adjusted for size and escalation between 1985 and present day using recognized cost ratios for combustion-boiler plants published by engineering organizations and in the literature (E.G. Chemical Engineering).

The organization providing the information is making it available for a small charge. The information is expected momentarily.

If the conclusions of the present study being funded by DOE are favorable, further efforts will be made to obtain funding to obtain actual designs and cost estimates from the boiler manufacturers to add to the credibility of the present study. The funding required will be in the \$100,000 range.

The \$99250 funding by DOE is now exhausted as shown on the Summary Financial Plan (last page of this report), and as shown in the detailed financial spreadsheets in Section 5. As agreed by R.W. Foster-Pegg, the project will be completed at no further expense to DOE. One more check in the amount of \$9261 is due to complete the \$99250 funding. This has been requested.

4.0 Project Task Reports

4.1 Task 1 - Selection of AE

4.1.1 Task Description

This task required: 1) Potential Contractor identification, 2) Contractor discussions to determine interest and capability, 3) Preparation of an RFP with detailed work scope description 4) Soliciting bids from qualified contractors, 5) Selection of the project AE.

4.1.2 Task Status and Activity in the Current Quarter

This AE contract has been signed for the work defined. The contractor has agreed to perform additional tasks should unforeseen but required work be identified as the project progresses. Any new work would be at additional cost.

4.2 Task 2 - Conceptual Design "CAT"

4.2.1 Task Description

The purpose of this task is to prepare a conceptual design and a cost estimate of a "CAT" plant on a hypothetical site, and to compare the capital cost and cost of power and steam from the "CAT" plant with power produced by alternate power plants on the same site.

Three "CAT" plant configurations will be investigated as follows:

Cycle A - Condensing "CAT"

- "Wet" condenser tower (or river) cooling
- Steam injection for peaking
- Coal fuel.

Cycle B - Cogeneration "CAT"

- Back-pressure steam turbine.
- Steam export and steam injection.
- Coal fuel.

Cycle C - Cogeneration "CAT"

- No steam turbine.
- Steam export and steam injection.
- Waste coal fuel.

Deliverables will include:

- Site layout drawings
- Equipment layout drawings
- Estimates of Total Plant Costs
- Estimates of the cost of power
- Final report

The final report will be the main report developed in the project and will include information developed/produced in other tasks and by Foster-Pegg Associates.

4.2.2 Task Status and Activity in the Current Quarter

- . Completed thermal designs, except for changes that might occur as result of new vendor data on the combustor system.
- . Cost estimates have been developed for the three cases, pending receipt of new information on the combustor system.
- . Developed reference plant costs from historical data. Preliminary cost comparisons have been made between the three CAT cases and the reference cases, pending receipt of new information on the combustor system.
- . Compiled and issued an interim study report.

4.2.3 Activity Planned in the Next Quarter

- . Incorporate FBC design information from outside suppliers into the conceptual designs of the three CAT cases.
- . Incorporate FBC cost information from outside vendor into the conceptual cost estimates of the three CAT cases.
- . Repeat cost comparisons between reference cases and the three CAT cases, using new combustor information to be received.
- . Use new dimensional envelopes for the FBC and its heat exchangers as received with new FBC information.
- . Issue final report.

4.3 Task 3 - Conceptual Design of Gas Turbine Modifications

4.3.1 Task Description

This task requires: 1)Identifying qualified contractors, 2)Discussing the requirement with prospective contractors, 3)Preparing a RFP to solicit bids, 4)Requesting bids, 5)Selecting a contractor

4.3.2 Task Status and Activity in the Current Quarter

The definition of modifications in more detail has been successful in obtaining commitments from contractors for the costing of this work. Revak Turbomachinery Services will do all modifications and Gilbert will do the piping.

4.3.3 Activity Planned in the Next Quarter

With contractors now identified for this work, this task can now proceed on a desirable schedule.

4.4 Task 26 - Combustion System Conceptual Design

4.4.1 This task was added during the first quarter in order to obtain more detailed design information and more accurate cost estimates on this very vital part of the "CAT" plant. This would include conceptual designs, performance and cost estimates of the Circulating Fluid Bed and Air Heater components for the 3 cycles being investigated. Information requested for each cycle includes:

- Specifications.
- Drawings for layout purposes.
- Costs for inclusion in the overall cost estimates.
- Performance.
- Descriptive Material for inclusion in a report.

This request includes all primary components and auxiliary elements needed for the combustion system.

4.4.2 Task Status and Activity in the Current Quarter

The information from an actual proposal has been shipped to R.W. Foster-Pegg in January and is expected to arrive by the end of January.

4.4.3 Activity Planned in the next Quarter

The combustion system information to be received soon will be use to retrofit details of the study to date to adjust for the final report.

4.5 Task 4 - Used Gas Turbine Survey

4.5.1 Task Description

The purpose of this task is to survey the availability and cost of used gas turbines. The scope of information desired is as follows:

- . Type and number of gas turbines offered for resale by year.
- . Type and number of gas turbines resold by year.
- . Sources of used gas turbines, by country, by industry.
- . Resale price range of gas turbines by type.
- . Cost of refurbishing resold gas turbines by type.
- . Cost of moving and installing pre-owned gas turbines by type.
- . List of vendors offering pre-owned gas turbines.
- . Purchasers of preowned gas turbines.
- . Impediments to the use of preowned gas turbines
Insurance, Financial, Utility commissions, etc.

4.5.2 Task Status and Activity in Current Quarter

All required information is available for this section of the final report.

4.5.3 Activity Planned in the next Quarter

Information obtained will be consolidated into the final project report.

4.6 Task 5 - CAT Competitive Analysis

4.6.1 Task Description

This task is to provide comparative results to be expected with a "CAT" plant relative to competitive alternative type plants.

4.6.2 Task Status and Activity in the Current Quarter

There has been no activity on this task.

4.11 Task 10 - Quarterly/Final Reports to DOE

4.11.1 Task Description

This task is to provide quarterly progress reports and a final report to DOE. As per the current schedules these reports will be as follows:

- . 1st Quarter Report for Oct-Dec 1994 due 1/31/95 (Delivered)
- . 2nd Quarter Report for Jan-Mar 1995 due 4/30/95
- . 3rd Quarter Report for Apr-Jun 1995 due 7/31/95
- . 4th Quarter Report for Jul-Sep 1995 due 10/31/95
- . 5th Quarter Report for Oct-Dec 1995 due 01/31/96
- . 6th Quarter Report for Jan-Mar 1996 due 4/30/96
- . Final Report due per new schedule on 6/30/96

Per the new project schedule, this project will be completed in March, 1996 so that the Final Report will be due 90 days following the end of the project.

5.0 Financial Status

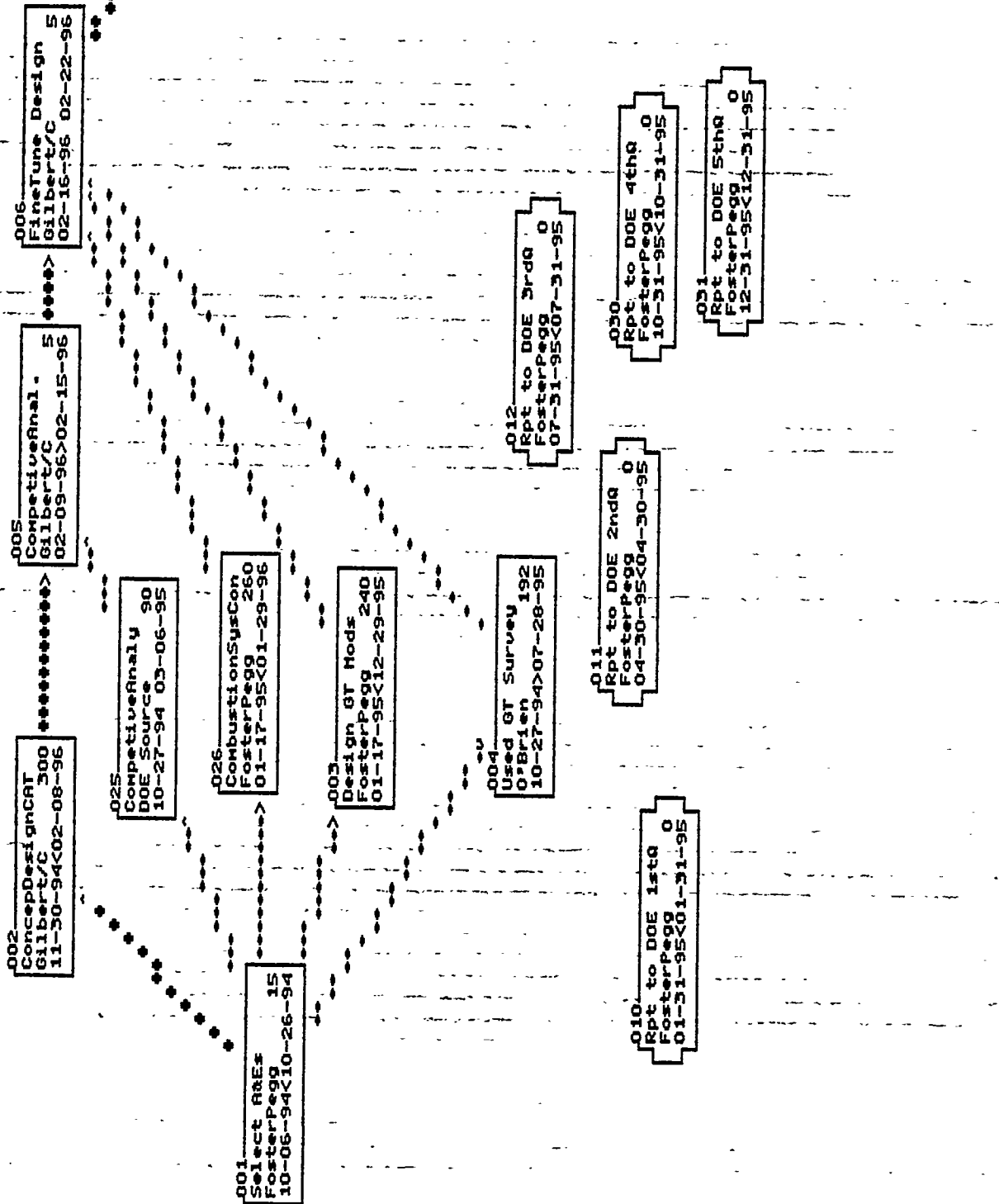
The plan submitted November 11, 1994 has continued to be modified to reflect the slower use of funds due to Gilbert/Commonwealth schedule change dictated by the delay in firming up of the design of the combustion system.

*Budget
Removed
at* This section shows the Sources and Uses of Funds Summary and the DOE Advance Payment Request Experience. This advanced payment process has been very satisfactory. Also provided in this section are the detailed spreadsheets which show the experience for the first quarter Oct-Dec 1994, the second quarter Jan-Mar 1995, the third quarter Apr-Jun 1995, the fourth quarter Jul-Sep 1995, and the fifth quarter Oct-Dec 1995.

6.0 Current Project Plan

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The following shows the updated PERT Chart for the project and the revised Financial Plan for the total project. As the Financial Plan shows, the \$99250 funding by DOE has been exhausted. However, as promised by R.W.Foster-Pegg, the project will be completed at no further cost to DOE.



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